The rate and mode of growth of banana leaves.

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The quick rate of growth of young banana trees is a matter of general observation. This unusual growth is, in itself, a subject of interest; and when viewed in comparison with the development of the sugar cane and other plants, and in the light of the general laws and conditions of vegetable growth, this great rapidity of development, by which it unfolds leaf after leaf, makes the banana a very conspicuous example, and it has led me to record data showing the daily increase in the length and substance of growing leaves.

The following observations were made upon banana trees growing in front of my veranda, which were planted in December. The data may appear to cover a large surface of paper; they were recorded, however, during the spare minutes around meal times, and may properly be called *a door step study*.

In the two first examples noted the young leaf was observed just as it emerged from its enclosure within the stem of the previously grown leaf, which mode of development it is instructive to watch. When fairly started, the length of the leaf was taken, and the measurement was repeated, at a given time, on each succeeding day, until the leaf was unfolded and full-grown.

The two following tables give the history of two leaves whose development was observed in the way explained. Observations were made upon no. 1 at 1 P. M., and upon no. 2 at 5:30 P. M. In all tables lengths are given in inches and temperatures in degrees Fahrenheit.

Leaf 1.

Date.	Length of Leaf.	Daily Growth.	Mean Temp.	Wind.
Jan. 26	6.5	0.0	70.5	N. E.
27	9.5	3.0	71.5	N. E.–S.
28	14.5	5.0	74.0	S.
29	20.5	6.0	76.5	S.
30	25.25	4.75	70.0	N.–N. E.
31	29.5	4.25	71.0	N.–N. E.
Feb. 1	35.0	5.5	73.0	N. E.
2	36.0	1.0	73.5	E.–N. E.

Leaf II.

Date.	Length of Leaf.	Daily Growth.	Mean Temp.	Wind.
Feb. 1	6.0	0.0	73.0	N. E.
2	9.75	3.75	73.5	E.–N. E.
3	13.5	3.75	74.0	N. E.
4	18.5	5.0	73.0	"
5	25.25	6.75	72.5	"
6	32.0	6.75	71.0	"
7	38.0	6.0	71.0	"
8	41.0	3.0	70.5	"
9	41.5	.5	68.5	"

The same observations were continued during the development of two more leaves, but with these examples the measurements were recorded twice daily for the purpose of noting the relative proportions of the day and night growths. The divisions of time were from 7:30 A. M. to 5:30 P. M., giving a period of day growth of ten hours; and from 5:30 P. M. to 7:30 A. M., giving a night period of fourteen hours. The day period represents approximately the hours that the sun was above the horizon.

Leaf III.—Night.

Date.	Length of Leaf.	Night Growth.	Night Temp.	Wind.
Feb. 9	0.0	0.0	65	N. E.
10	5.75	.75	64	"
11	8.75	1.25	66	"
12	13.25	1.25	62	N.–N. E.
13	16.5	1.0	60	"
14	22.25	2.0	65	S.
15	28.0	1.5	61	S. E.
16	35.5	3.0	62	N. W.
17	41.5	1.0	62	W.–S. W.
18	45.25	.75	62	S.
19	47.0	.5	63	S. W.

Leaf III.—Day.

Date.	Length of Leaf.	Day Growth.	Day Temp.	Total Daily Growth.	Wind.
Feb. 9	5.0	0.0	76	0.0	N. E.
10	7.5	1.75	73	2.5	"
11	12.0	3.25	75	4.5	"
12	15.5	2.25	75	3.5	N.-N. E.
13	20.25	3.75	76	4.75	"
14	26.5	4.25	78	6.25	S.
15	32.5	4.5	76	6.0	S. E.
16	40.5	5.0	77	8.0	N. W.
17	44.5	3.0	78	4.0	W.-S. W.
18	46.5	1.25	79	2.0	S.
19	48.0	1.0	78	1.5	S. W.

Leaf IV.—Night.

Date.	Length of Leaf.	Night Growth.	Night Temp.	Wind.
Feb. 26	5.5	0.0	67	E.-N. E.
27	8.5	.75	72	S. W.
28	10.75	.75	71	E.-N. E.
29	13.5	1.0	67	S. W.
Mar. 1	16.5	1.25	67	S.
2	19.25	.75	65	S. W.
3	23.25	1.25	64	E.-W.
4	28.0	2.0	61	W.-S. W.
5	36.5	2.75	62	W.-S. W.
6	44.75	1.25	64	N.
7	48:5	.75	65	N. E.
8	50.5	.5	65	N. E.
9	52.75	.25	66	N. E.

Leaf IV.—Day.

Date.		Length of Leaf.	Day Growth.	Day Temp.	Total Daily Growth.	Wind.
Feb.	26	7.75	2.25	78	0.0	E.–N. E.
	27	10.0	1.5	78	2.25	S. W.
	28	12.5	1.75	80	2.5	E.–N. E.
	29	15.25	1.75	80	2.75	S. W.
Mar.	1	18.5	2.0	81	3.75	S.
	2	22.0	2.75	77	3.5	S. W.
	3	26.0	2.75	72	4.0	E.–W.
	4	33.75	5.75	78	7.75	W.–S. W.
	5	42.0	5.5	80	8.25	W.–S. W.
	6	47.75	3.5	77	5.75	N.
	7	50.0	1.5	76	2.25	N. E.
	8	52.5	2.0	77	2.5	N. E.
	9	53.25	.5	76	.75	N. E.

Before speaking in detail of the data presented by the four tables giving the history of each leaf, for convenience, we shall bring these data together in a table of averages, in which are given the length, breadth, and surface development of the leaves, with the more detailed data. The "length of leaf" given is the total length of the mature leaf, less its length at the time of the first measurement. This correction is necessary, or the total "surface of the mature leaf," and the "daily surface growth" would be given too high.

The averages are as follows:

No. of Leaf.	Length of Leaf.	Breadth of Leaf.	Surface of Leaf. Sq. in.	Mean Growth of Day Period.	Mean Growth of Night Period.	Mean Daily Growth.	Mean Daily Surface Growth. Sq. in.	Mean Temp. of Growth.
No. I.	29.5	14	413	...	...	4.25	59.0	72.5
II.	35.5	14	497	...	...	4.5	62.0	72.0
III.	43.0	15	645	3.0	1.33	4.33	64.5	70.0
IV.	47.5	17	803	2.6	1.2	3.8	66.9	71.7

The first thing to which attention is called in this table is the mode of development. In the first place, a striking uniformity of growth is noted, and at the same time a gradual increase in the tree's capacity of assimilation, which is shown by the gradual increase in the "mean daily surface growth" from leaf I up to IV. I will state that these observations were made on one banana tree only, in order to exclude individual errors arising from the differences in individual trees, and that the four leaves were developed one after the other. This statement enables me to explain that the gradual increase in the daily surface growth from I to IV is due to the increasing area of assimilating surface. Each succeeding leaf has the last additional one to assist in gathering food for its growth, and the work goes more rapidly.

The increase in the rate of assimilation with the addition of new leaves is less than I expected to find. It is not in any way proportional to the increase of leaf surface; and this suggests that the chief burden in the work of making the next new leaf lies upon the previous leaf that was made. This is also further suggested by the banana tree's mode of growth. The banana appears to have only one center of growth and elaboration; it makes only one leaf at a time, and practically completes one leaf before it begins with the next. Many other trees are producing scores of leaves at the same time, showing that centers of work are distributed over the tree's complete organism. Moreover, the full grown leaves of the banana are soon frayed out with the wind and rendered useless for work, which forces the work of assimilation upon the new leaves. The details in the tables also show strikingly the variation in the rate of growth along the period of development. The young leaf begins slowly, daily increasing its rate of increase up to the stage of its maximum power of growth, where it tarries for two or more days, until the leaf, which hitherto has been almost as tightly rolled up as a cigar, begins to unfold to the light, when the rate of growth falls off till it is full grown. In the history of the four leaves this mode of growth is seen to obtain.

One other striking truth set forth by the daily data of development is the difference between the growths of the "day" and "night" periods. The observations were continued upon leaves III and IV not only to compare the results of the day and night growths, but also to note the results of variations

of temperature. The mean night growth of leaves III and IV was 1.25 inch, and the mean daily growth was 2.8 inch, which shows that about 70 per cent. of the total growth took place during the day, between 7:30 A. M. and 5:30 P. M. It also illustrates the effect of length of day.

The effect produced by variations of either day or night temperatures it is not easy to decide. In leaf I, for example, it is strongly indicated that the sudden and great fall of temperature on Jan. 30th, continuing over Jan. 31st, caused a decrease in the growth of the leaf. In the other examples, such as IV, a small fall in the night temperature, as on March 4th, does not at all interfere with the maximum growth. From this it appears that a great lowering of the temperature is necessary to seriously arrest progressive growth.

I am of opinion that the action of direct sunlight, and the direction and force of the wind, are more potent factors in increasing or arresting growth than small variations of temperature. On this subject I have, at present, no conclusive data.

The banana is an excellent subject in which to study given features of physiological development. The growth of its leaves is so rapid that measurements can be recorded twice daily with a measuring rule, and with the possibility of extremely small error. This is of great value in affording light upon the laws and conditions affecting the growth of other plants. The sugar cane, for example, grows so comparatively slowly that with it such observations as I have recorded are not possible. It will probably not be far wrong, however, if the data obtained in observing the banana are applied in judging of the influences which affect the growth of cane and other plants.

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